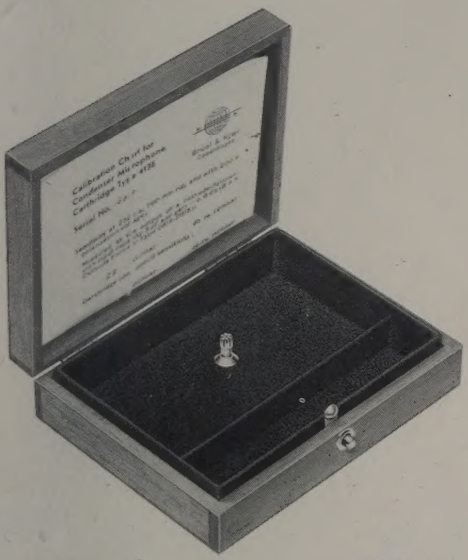
4138

INSTRUCTIONS AND APPLICATIONS

Eighth-inch Condenser Microphone

Microphone Cartridge Type 4138
Cathode Follower Type 2615
with Adaptor UA 0036



Precision condenser microphone for special measurement purpose. Each microphone is individually calibrated. Frequency-range of calibration: 30 Hz — 140 kHz. Dynamic range: 76—184 dB.

BRÜEL & KJÆR
NÆRUM, DENMARK. Teleph.: 80 05 00. Cable: BRUKJA. Telex: 5316. COPENHAGEN

- Accelerometers
- Acoustic Standing Wave Apparatus
- Artificial Ears
- Artificial Voices
- Audio Frequency Response Tracers
- Audio Frequency Spectrometers
- Audio Frequency Vacuum-Tube Voltmeters
- Automatic A. F. Response and Spectrum Recorders
- Band-Pass Filter Sets
- Beat Frequency Oscillators
- Complex Modulus Apparatus
- Condenser Microphones
- Deviation Bridges
- Distortion Measuring Bridges
- FM-Tape Recorders
- Frequency Analyzers
- Frequency Measuring Bridges
- Hearing Aid Test Apparatus
- Heterodyne Voltmeters
- Level Recorders
- Megohmmeters
- Microphone Accessories
- Microphone Amplifiers
- Microphone Calibration Apparatus
- Mobile Laboratories
- Noise Generators
- Noise Limit Indicators
- Pistonphones
- Polar Diagram Recorders
- Preamplifiers
- Precision Sound Level Meters
- Recording Paper
- Strain Gage Apparatus and Accessories
- Stroboscopes
- Variable Frequency Rejection Filters
- Vibration Pick-ups
- Vibration Pick-up Preamplifiers
- Wide Range Vacuum Tube Voltmeters
- Vibration Programmers
- Vibration Control Signal Selectors
- Vibration Control Generators
- Vibration Meters

Eighth-inch
CONDENSER MICROPHONES

PROPERTY OF DEPT. C-270
METROLOGY LAB.
DO NOT REMOVE
FROM AREA

September 1967

Contents

0. Introduction

Definitions of Free-field and Pressure Response 3
Random Incidence Response (Diffuse Field Response) 4

1. Description

General Description of the Equipment 5
Eighth-inch Condenser Microphone Cartridges 6
Cleansing of the Microphone Diaphragm 8
Associated Cathode Follower Type 2615 + UA 0036 8
Characteristics of the Eighth-inch Microphones 12
1. Sensitivity 12
2. Frequency Response 12
3. Free Field Corrections 14
4. Directional Characteristics 14
5. Dynamic Range (Noise and Distortion) 15
6. Equivalent Air Volume 16
7. Influence of the Polarization Voltage 16
8. Temperature Characteristics 16
9. Influence of Ambient Pressure 16
10. Influence of Humidity 17
11. Influence of Vibrations 18
12. Sensitivity to Magnetic Fields 18

2. Accessories

Microphone Stand UA 0049 19
Extension Cables AO 0027–28–29, AR 0001 19
Mechanical Adaptor DB 0900 20
Probe Microphone Kit UA 0040 21
Two-Channel Selector 4408 22
Microphone Power Supply 2801 23
Two-Channel Power Supply Type 2803 24

Appendix

Principle of the Condenser Microphone 25
Microphone Calibration 26
Pistonphone 4220 27
Electrostatic Actuator UA 0033 28
The Range of B & K Condenser Microphones 30

Specifications

Survey of Accessories 33
Comparative specifications 34

0. Introduction

Definitions.

Free-field and Pressure Response.

The *Free-field Response* of a microphone is the ratio of the RMS output voltage to the RMS sound pressure existing in the free field at the microphone location with the microphone removed from the sound field.

The *Pressure Response* of a microphone is the ratio of the RMS output voltage to the RMS sound pressure, uniformly applied over the diaphragm. The two definitions coincide for a microphone having negligible dimensions with respect to the sound wavelength.

At higher frequencies the diffractions of the sound waves on the microphone produce an appreciable change in the resulting sound pressure acting on the microphone diaphragm as illustrated in Fig. 0.1. The difference $p_1 - p_0$, called *free-field correction,* depends on the orientation of the microphone with respect to the direction of propagation of the sound and on the external dimensions of the microphone (in particular those of the front and of fitted protective grids or "nose cones").

The free-field behaviour of a microphone is thus described by means of a set of free-field correction curves for various incidences, which should be added to the pressure frequency curve of the microphone in each particular case.

For microphones intended for free-field work it is possible to give the diaphragm resonance such a damping that the normal incidence free-field corrections are compensated for up to frequencies well above the resonance frequency, in order to obtain the flattest possible frequency response.

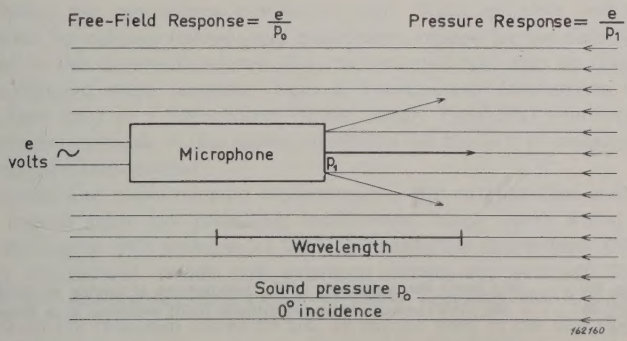


Fig. 0.1. Definitions of Free-field and Pressure response.

Random Incidence Response (Diffuse Field Response).

The random incidence response of a microphone for a given frequency is the RMS value of the free field sensitivity for all angles of incidence of the sound wave. It corresponds to the diffuse field sensitivity of the microphone, the diffuse field being a sound field in which the sound energy density is uniform and the mean acoustic power per unit area is the same in all directions. The International Electrotechnical Commission (publication no. 123, § 8.2) has given a practical rule for the calculation of the random incidence sensitivity from the free-field sensitivities at definite angles, with coefficients proportional to the relative solid angles.*)

When the spectral distribution of the sound varies with the angle of incidence, correct integration is only possible in the range where the microphone is both linear and omnidirectional (practically up to 30 kHz with the eighth-inch microphones).

Omnidirectional microphones are also necessary in the case of rapidly moving sound sources (aeroplanes, motorcars, etc.).

---

*) S_0, S_{30}, S_{60} - - - - S_{180} being the sensitivity of the microphone at angles of incidence of 0°, 30°, 60°, - - - - 180°, the random incidence (diffuse field) response S is given by the formula:

$$S^2 = 0.018\ (S_0^2 + S_{180}^2) + 0.129\ (S_{30}^2 + S_{150}^2) + 0.224\ (S_{60}^2 + S_{120}^2) + 0.258\ S_{90}^2$$

1. Description

General Description of the Equipment.

A complete microphone consists of a microphone cartridge and a cathode follower for impedance conversion, allowing long cables and relatively low input impedance amplifiers to be used between the microphone and the measuring instrument. The microphone cartridge is screwed onto the housing of the cathode follower by means of an adaptor making a small, rugged unit. Fig. 1.1.

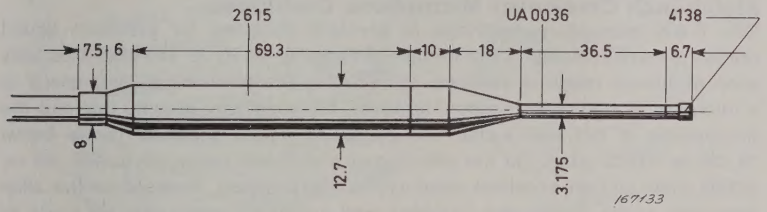


Fig. 1.1. Eighth-inch microphone with outer dimensions in mm (1 mm = 0.03937 inch).

The microphone may be directly connected to the different B & K measuring instruments which are provided with a CONDENSER MICROPHONE input socket fitting the microphone connecting plug. Stabilized plate and heater voltages for the cathode follower and polarization voltage for the cartridge are available on this seven-pin socket. The microphones may also be used with other equipment when operated from a Two-Channel Microphone Power Supply Type 2803 or a Microphone Power Supply Type 2801 which provide the necessary voltages in the same conditions as the B & K measuring instruments (see Accessories).

For free-field and room-acoustic measurements, the microphones should be placed remote from the measuring instruments, since these would often disturb the sound field because of their non-negligible dimensions. Different types of microphone stands and extension cables are available for this purpose, see Accessories. The length of cable, however, has a significant influence on the response above 40 kHz as will be seen in the description of the cathode follower.

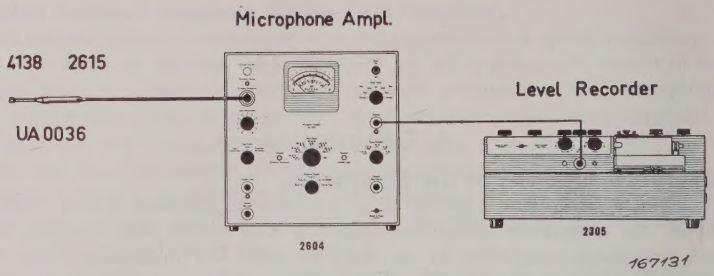


Fig. 1.2. Typical B & K measuring equipment. Both amplifier and level recorder are linear up to 200 kHz. A filter set (Type 1612) is also available for automatic plotting of spectrograms in the range 22 Hz–45 kHz.

Eighth-inch Condenser Microphone Cartridges.

This B & K microphone cartridge is specially designed for precision sound pressure measurements in the frequency range of 30 Hz to 140 kHz. This very wide frequency range is obtained by reducing the mechanical dimensions to a minimum. For this very reason, however, the sensitivity is quite low and the microphone is not well suited for measuring sound pressure levels below 76 dB re. 0.0002 μbar. On the other hand a dynamic range up to 184 dB re. 0.0002 μbar and an excellent response to sharp pulses, because of the wide frequency range, makes the cartridge well suited for measuring all kinds of noise at high pressure levels (e. g. missile exhaust noise etc.).

Excellent long term stability under a great range of environmental conditions and especially insensitivity to temperature variations ensures that even for field measurements the accuracy of calibration matches laboratory standard requirements.

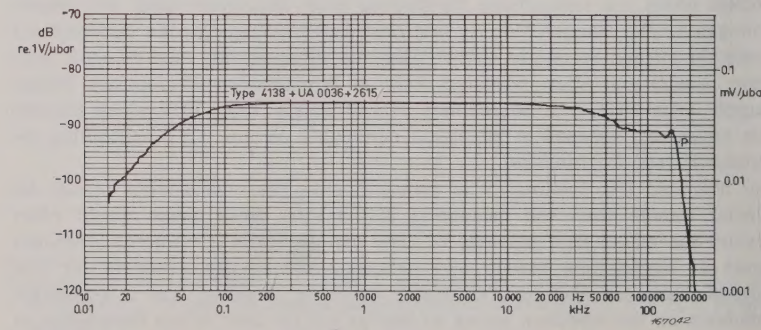


Fig. 1.3. Most significant pressure response of the eighth-inch microphone.

The characteristic of the Microphone Cartridge Type 4138 is illustrated in Fig. 1.3. It is based on an extremely accurate mechanical construction. Fig. 1.4 shows a cross section of the microphone cartridge. The thickness of the diaphragm (approximately 2 μ), the shape of the back plate and the distance (12–13 μ) between membrane and back plate is determined so that a critical damping of the diapragm resonance is achieved. In this way the widest possible flat frequency range of the pressure response is obtained.
The pressure increase with the protection grid mounted is appreciably higher and at high frequencies it is rather dependent on how tightly the grid is screwed onto the cartridge. Measurements involving ultrasonic frequencies should therefore be carried out with the protection grid removed.
Towards the low frequencies the response of the cartridges is only affected by the influence of the *pressure equalizing arrangement*. This arrangement

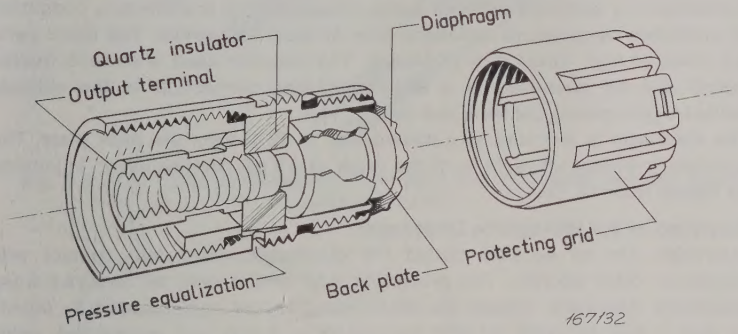


Fig. 1.4. Exploded view of a 1/8" microphone cartridge.

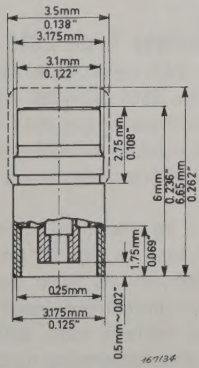


Fig. 1.5. Dimensions of the 1/8" microphone cartridge Type 4138.

consists of a capillary leakage hole through which the equalization of the static air pressure on both sides of the diaphragm is obtained at a suitable rate. The influence of ambient pressure (or altitude) variations on the microphone sensitivity has been practically eliminated by proper design of the pressure equalization hole. The time constant of the pressure equalization of the eighth-inch cartridges corresponds to a -3 dB cut-off frequency of 30 Hz and will not influence the measurements, since the -3 dB low frequency cut-off of the complete microphone is > 5 Hz.

The choice of the materials and the design of the suspensions of the different parts are made principally in order to obtain the best possible long-term *stability* and temperature independency of the sensitivity.

In particular, the diaphragm is not clamped but electro-deposited onto the tensioning ring, forming one mechanical piece. The tension of the diaphragm is thereby unaffected by temperature variations. The cartridges are also subjected to a complete artificial aging process during manufacture consisting of controlled temperature variations over at least two weeks. The basic parts are made of high nickel alloy (K-Monel). The insulator used is silicone treated quartz and for guaranteeing a disturbance-free connection to the cathode follower, gold-plated contacts are used.

The diaphagm is mounted at a distance of 12–13 μ from the back plate. The *polarized cartridge capacity* is of the order of 3.5 pF. The insulation is verified as higher than 10^5 MΩ.

Cleansing of the Microphone Diaphragm.

CAUTION. On no account should the diaphragm come into contact with fingers or other objects. The protecting grid should only be removed when absolutely necessary. Should the diaphragm become contaminated by liquids or dust it may be dried off with cottonwool or a very soft paint-brush, using great care, and if necessary a proper solvent. The diaphragm will not normally corrode, but any appreciable added mass will change the frequency response.

Associated Cathode Follower Type 2615 + UA 0036.

The eighth-inch microphone cartridges Type 4138 are intended to be used with the cathode follower Type 2615 provided with an adaptor Type UA 0036. The "goose-neck" cathode follower Type 2614 may be used instead of the 2615 but it is then necessary in order to obtain identical results above 40 kHz to load the output of the 2614 with a capacitance of 600 pF (e.g. the 10 m long cable Type AO 0028).

Note: On no account should it be attempted to bend the Adaptor UA 0036.

A photograph of the 2615 is seen in Fig. 1.6 and the basic diagram is given in Fig. 1.7. The electrical components have been divided into two groups. Those belonging to the high impedance input circuit are mounted in the main housing containing the vacuum tube, while all parts on the low impedance side are located in the connecting plug. A two-meter long multicore cable is inserted between housing and plug. The dimensions of the housing

are thus reduced to a minimum: diameter 12.7 mm (1/2″), length approx. 7 cm (2¾″). See also Fig. 1.1. The components, which are compactly mounted on a teflon base, have been carefully selected in order to ensure high operating stability under the most severe environments.

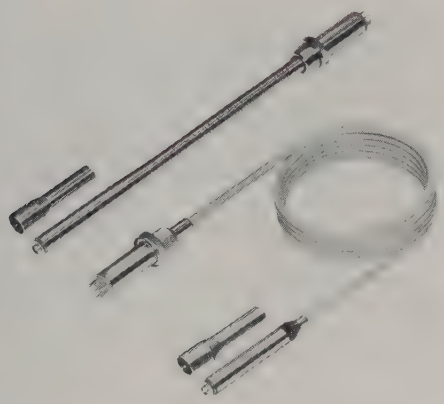


Fig. 1.6. The Cathode Followers Type 2614 and 2615 with included input adaptor JJ 2614.

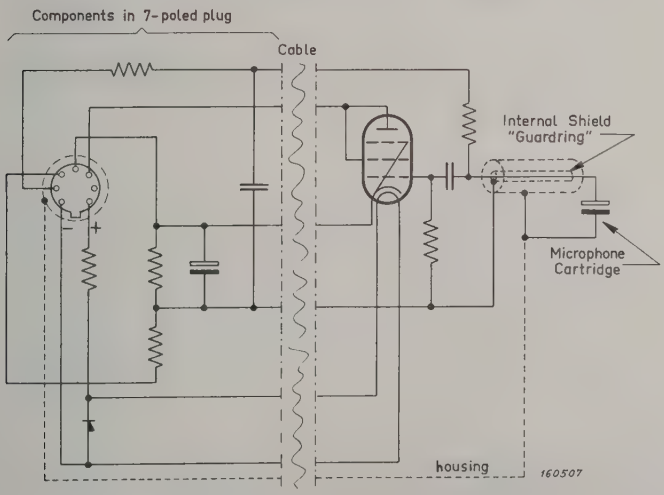


Fig. 1.7. Basic diagram of the cathode-follower showing the principle of the guard ring system.

Before mounting each tube is tested for sensitivity to shock according to the Mil-EIC specifications. In addition, during the final test the cathode followers are exposed to a sound pressure of 130 dB where their microphonics are checked to be smaller than 8 mV throughout the frequency range 20–20000 Hz (Fig. 1.8).

The input circuitry is internally screened by means of a "guard ring" which is connected to the cathode of the tube. In this way the input capacity is reduced to an absolute minimum. The guard ring is extended to the top of the cathode follower which allows the use of low capacity extension connectors such as UA 0036 between microphone cartridge and cathode follower. The capacitive load due to the three signal conductors of the multi-core cable causes, through the guard ring circuit, the input capacity to increase with frequency. When adjusting the frequency response of the cartridge this loss is taken into account in order to provide a flat frequency response of the complete microphone.

The power supplies necessary to operate the cathode followers are provided by the B & K measuring amplifiers, or the Two-Channel Microphone Power Supply Type 2803 or the Microphone Power Supply Type 2801, via the multipin-socket at the front panel as shown in Fig. 1.10.

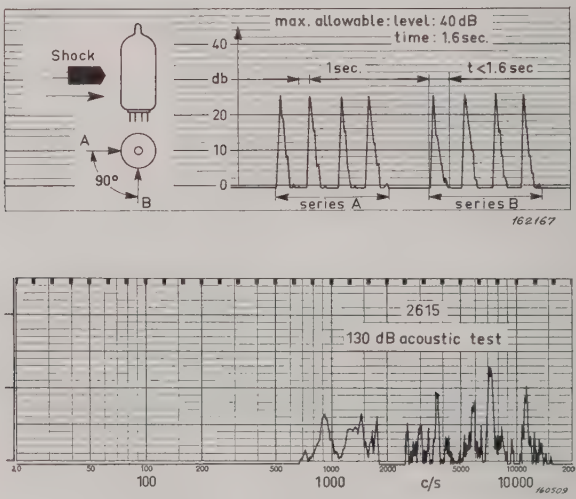


Fig. 1.8.

(a) Test of a tube EF 731. Microphonics are excited by means of two series of lateral shocks and recorded whereby the amplitude and duration of transients are closely checked.

(b) Recording of the output from a 1/2" cathode follower loaded by a 6 pF dummy cartridge, exposed to a sound field of 130 dB at varying frequency.

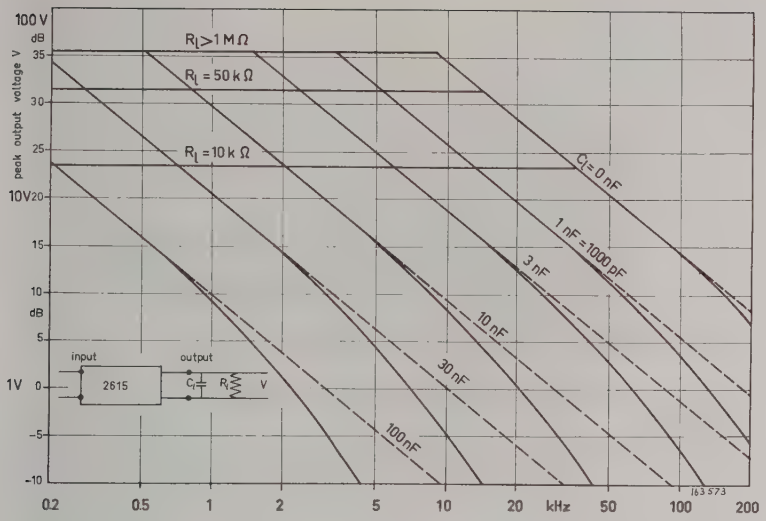


Fig. 1.9. Upper limit of the dynamic range of the cathode follower. The limit given by this graph is the peak output voltage corresponding to a distortion of 4 % as a function of frequency and loading. The dashed lines show the corresponding input voltage (minus 0.9 dB).

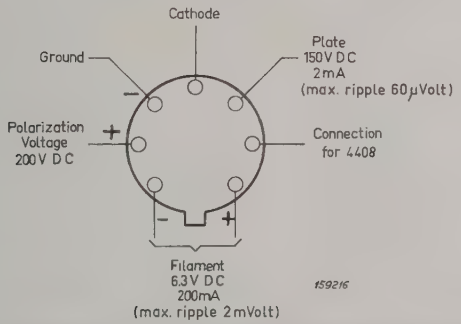


Fig. 1.10. Plug connection of the cathode follower (viewed externally).

The cathode followers can be used separately whenever a high input impedance amplifier is needed for voltage measurements at the output of small transducers etc. An input adaptor JJ 2614 is supplied for this purpose with each cathode follower, as seen in Fig. 1.6. This adaptor can be screwed onto the cathode follower housing instead of the UA 0036 and contains a capacitor of a few thousand pF for blocking the 200 V DC polarization

voltage. The adaptor provides a standard 14 mm coaxial socket fitting the B & K JP 0018 plug.

Specifications.

Input Impedance: 700 MΩ in parallel with 3 ± 0.5 pF.
Below 10 Hz and above 2 Hz: more than 200 MΩ in parallel with 3 ± 0.5 pF).

Output Impedance: Approximately 750 Ω.

Transmission Loss: Voltage gain = – 0.9 dB ± 0.2 dB.

Self-generated Noise Level: Approximately 80 μV at cathode follower output, with the input loaded by a capacitor of 8 pF (20 Hz–200 kHz).

Distortion: 4 % distortion occurs with input voltages higher than 20 volts RMS at 1 kHz. (See Fig. 1.10 for higher frequencies).

Tube: 5899 (EF31), specially tested for low microphonics.

Characteristics of the Eighth-inch Microphones.

1. Sensitivity.

The nominal sensitivity of the eighth-inch microphone is 50 μV/μbar (– 86 dB re 1 V/μbar). However, the cartridges are individually calibrated and the actual sensitivities may lie between ± 3 dB of the nominal values.

On the calibration chart (Fig. 1.11) which is delivered with each cartridge is also given the cartridge open circuit sensitivity (about 5 dB higher than the sensitivity of the complete microphone depending on the cartridge capacity) and a factor K equal to the difference between the microphone sensitivity to which the sound level graduation of the B & K instruments is referred and the particular microphone sensitivity.

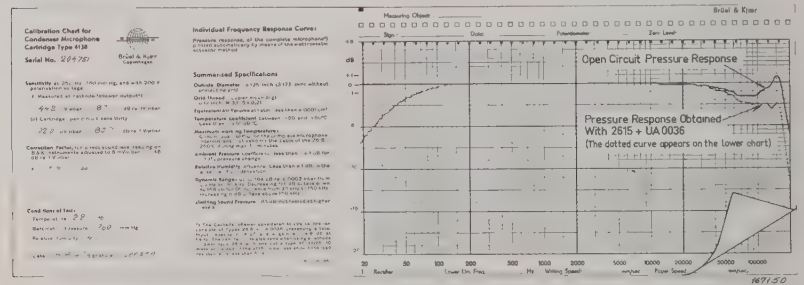
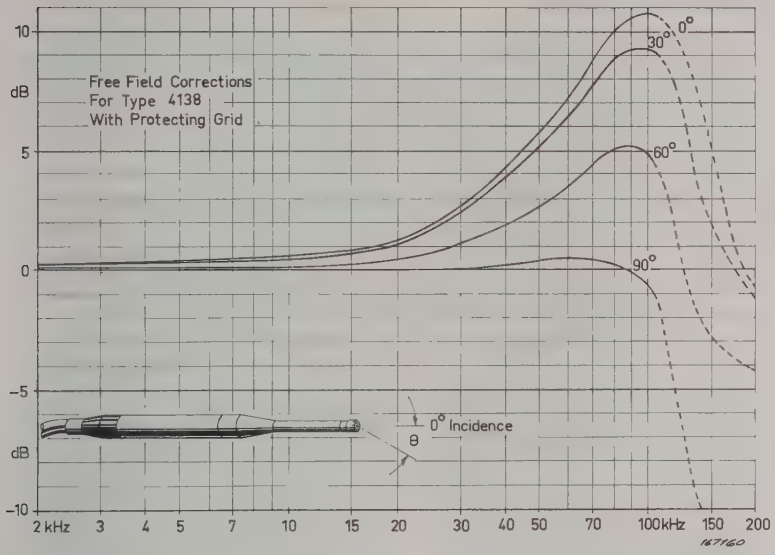


Fig. 1.11. Calibration charts supplied with each microphone cartridge. The pressure response is automatically plotted by a process having an accuracy of ± 0.2 dB up to 10 kHz and ± 0.5 dB up to 200 kHz.

2. Frequency Response.

The frequency characteristics given in Fig. 1.11 are the open circuit pressure response, which is defined as the ratio of the RMS output voltage to the RMS Sound pressure, uniformly applied over the diaphragm, and the pressure response curve obtained on 2615 + UA 0036.



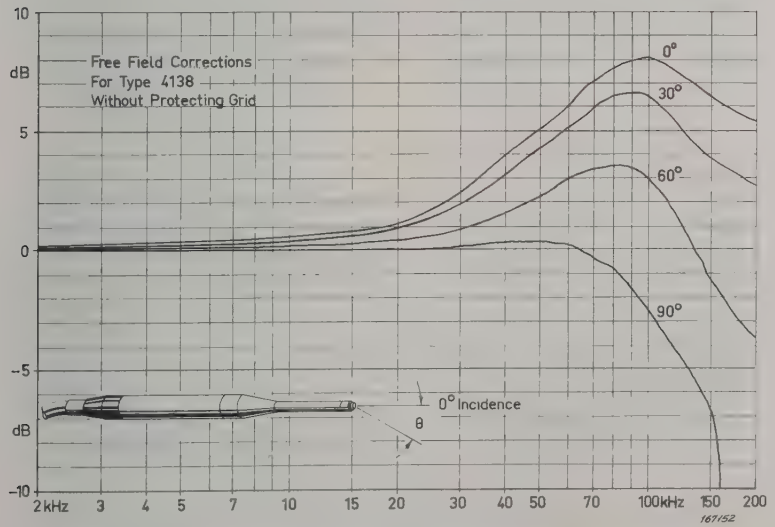


Fig. 1.12. Free field corrections for the eighth-inch microphone.

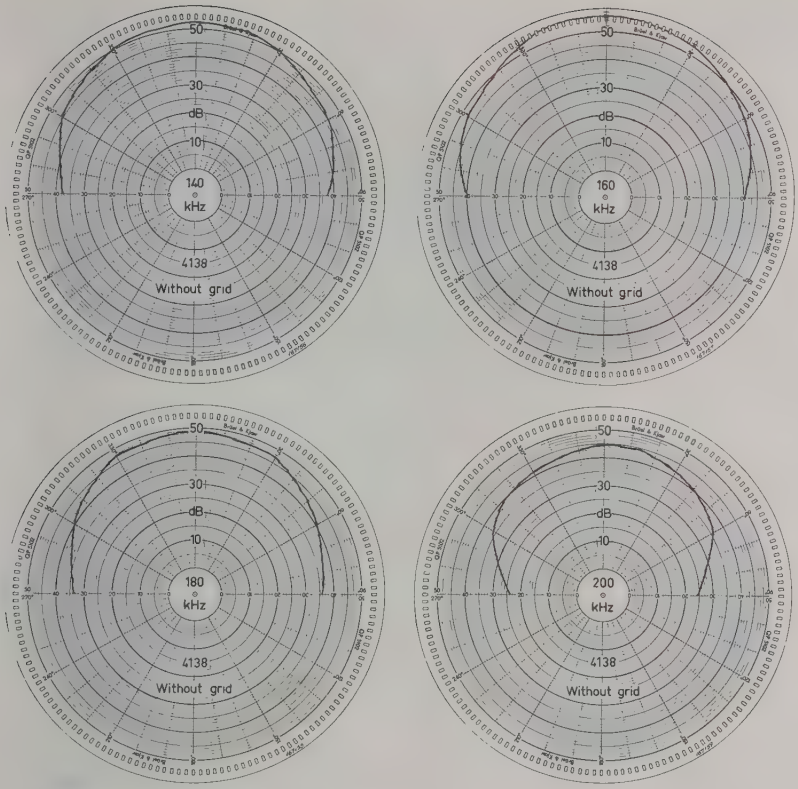
3. Free-field corrections.

The free-field correction curves for incidences from 0° to 180° are given in Fig. 1.12. They are only well defined for the microphone without protecting grid at high frequencies because the wavelength being only a few millimeters interfers with the dimensions and position of the grid slots. (The wavelength in air is 1.6 mm at 200 kHz).

4. Directional Characteristics.

From Figs 1.12 to 1.13 is seen that the eighth-inch microphones are omni-directional within ± 3 dB up to 60 kHz.

Fig. 1.13. Directional patterns of the eighth-inch microphones.



5. Dynamic Range (Noise and Distortion).

The lower limit of the dynamic range is set by the thermal noise level of the cathode follower with input loaded by the cartridge capacitance. This noise level is less than 60 μV when filtered by a standard weighting curve A, and about 80 μV when considering the maximum range 20 Hz to 200 kHz. The corresponding sound level limits are 76 dB for a 4138 with sensitivity 50 μV/μbar. When taking measurements through third-octave filters for analysis with B & K instruments Types 1612/2112/2211/2212, the noise level is rejected so as to be less than 7 μV.

The upper limit of the dynamic range is set by the harmonic distortion which appears both in the cartridge and the cathode follower when the output voltage attains 10–20 volts (less above 40 kHz as seen from Fig. 1.9). The corresponding sound pressure level is 185 dB. The level at which the contact between diaphragm and back plate is possible is only a few dB

above these values, and the cartridges should not be exposed to levels exceeding 185 dB.

6. Equivalent Air Volume.

At frequencies up to 110 kHz where the motion of the microphone diaphragm is controlled only by stiffness, the acoustical impedance of the microphone is capacitive. In dealing with closed cavity measurements (coupler measurements) in this frequency region it is therefore convenient to express the impedance in terms of an equivalent volume V_e:

$$V_e = \frac{\gamma P}{j \omega Z_e}$$

where γ = ratio of specific heats (1.41) P = ambient pressure and Z_e = acoustical impedance of the microphone. The equivalent volume of the eighth-inch microphones being, however, smaller than 0.0001 cm^3 it will be negligible in the greater majority of cases.

7. Influence of the Polarization Voltage.

The condenser microphone cartridges have been designed to operate with a polarization voltage of 200 volts.

The polarization voltage supplied from the instrument to which the condenser microphone is connected should be adjusted to 200 volts before measurements are taken. Adjustment instructions will be found in the respective manuals.

If the eighth-inch cartridges are operated with other polarization voltages (from 150 to 250 volts) the sensitivity is modified proportionally. The shape of the frequency response curve remains practically unchanged (within $\pm$ 0.2 dB). The cartridges are not tested above 250 volts.

8. Temperature Characteristics.

As mentioned in the description, special care has been taken during the development and subsequent manufacture of the microphone cartridges to obtain a characteristic which to a high degree is independent of temperature. The cartridges and adaptor UA 0036 stand temperatures of up to 150°C (300°F) continuously and up to 250°C in short periods (10 min.). However, the insulation material used in the connecting cables of the cathode followers 2615 should not be exposed to higher temperatures than 100°C (212°F).

Note: Subjecting the eighth-inch cartridges to temperatures around 200°C during more than 10 minutes will not damage the microphones but will produce a permanent change in characteristics.

9. Influence of Ambient Pressure.

The microphone sensitivity will vary less than $-$ 0.1 % for $+$ 10 % variations in ambient pressure. For important changes in ambient pressure the frequency response of the microphone will be modified, especially towards

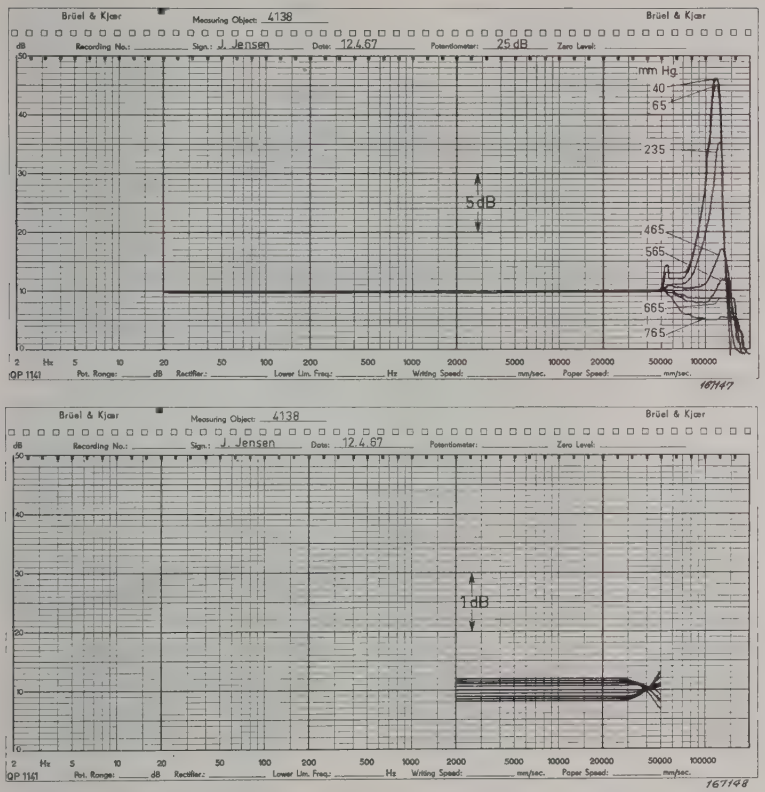


Fig. 1.14. Influence of the static ambient pressure on the frequency response of the eighth-inch microphone.

the higher frequencies because of the change in mechanical damping. The frequency response at different ambient pressures is given in Fig. 1.14. The influence of varying altitude is very small: a rate of climb of 10 km/sec at ground level affects the sensitivity less than 1 dB.

10. Influence of Humidity.

Large variations of ambient temperature may in some cases cause moisture condensation to take place between the diaphragm and the electrode of the cartridges. There is then a temporary risk of electrical noise and cracking. When stable ambient conditions are regained, the condensed water will evaporate within less than 15 minutes through the pressure equalization aperture. A complete description of these phenomena will be found in the

B & K Technical Review No. 1-1960, p. 12–15. A fully protected microphone system for permanent exposure outdoors is available in the half-inch range (Type 2615 + 4133 + UA 0056).
In the absence of condensation, the relative humidity percentage has practically no influence on the microphone sensitivity.
N.B. The use of dessicators during storage is not recommended.

11. Influence of Vibrations.
The influence of a vibration will depend on the direction in which it is applied to the microphone. When the force is acting in a direction which is parallel to the axis of symmetry (i.e. at right angles to the diaphragm) the sensitivity to vibration is mainly determined by the mass of the diaphragm and of the air column on both sides of it. The microphone will be most sensitive to vibration acting in this direction, but due to the low diaphragm mass, the signal produced from vibrations having an acceleration of 1 g is a low as an equivalent sound pressure level of approximately 90 dB. The sensitivity to vibrations acting at right angles to the axis of symmetry (parallel to the diaphragm) is determined by the electrodes of the cathode follower tube.

12. Sensitivity to Magnetic Fields.
The sensitivity to magnetic fields is extremely low. Even with a very intense field of 50 oersted at 50 Hz having the most unfavorable orientation, the induced output does not exceeded 0.1 mV fundamental and 0.3 mV second harmonic (100 Hz).

2. Accessories

Microphone Stand UA 0049.

This stand fitting all types of B & K microphones is of invaluable assistance in field measurements. It is a lightweight portable tripod with rigid telescopic legs, similar to those used in photographic work, as shown in Fig. 2.1. The height of the Stand can be adjusted from approximately 50 cm to 140 cm. The Tripod Adaptor UA 0028 (seen on top of UA 0049) may be used separately for adapting the microphones on standard camera tripods with 3/8" W thread.

Fig. 2.1. Microphone Stand UA 0049.

Extension Cables.

When it is desired to use the microphone at a distance from the associated instruments an extension cable must be used to make the connection. Several standard lengths of extension cables are available for this purpose.

The conductors are polyethylene insulated and the cable is covered with a grey P.V.C. covering.

Extension Cable AO 0027 is a 3 m long multi-core shielded cable supplied with B & K microphone connectors at both ends. The diameter is 6 mm.

The capacity of the signal conductor to ground is approximately 100 pF/m.

Extension Cable AO 0028 is a 10 m long multi-cored shielded cable, supplied with a coaxial signal conductor and B & K microphone connectors at both

ends. The diameter is 9 mm. The cable is specially designed to give low microphony, excellent shielding of the signal core and low leakage between the cores enable long runs of cables to be used.
The capacity of the coaxial signal conductor to ground is approximately 57 pF/m (19 pF/foot). It is possible to use cable lengths of up to 200 m, see Fig. 1.9. If larger cable lengths are to be used, the filament series resistor, included in the normal B & K microphone amplifier, should be adjusted so that the filament voltage on the cathode follower tube is 6.3 volts.
Extension Cable AO 0029, as for AO 0028, but 30 m long.
Tape Microphone Cable AR 0001. This very flexible, flat 7-cored microphone cable is used when sound insulation and reverberation measurements are made in buildings and where it is necessary to carry a microphone cable through closed windows and doors. The flat cable can easily follow sharp bends, the thickness of the cable being 0.2 mm. Cable length: around 30 cm.

Mechanical Adaptor DB 0900.

By screwing the adaptor DB 0900 onto the eighth-inch cartridge, a device having the same external dimensions as the B & K half-inch microphone cartridges Type 4133/34 is obtained. This enables the accessories types UA 0033 (electrostatic actuator, see Appendix) or UA 0040 (see below) etc., which were originally designed for the half-inch microphones, to be used with the eighth-inch microphones.

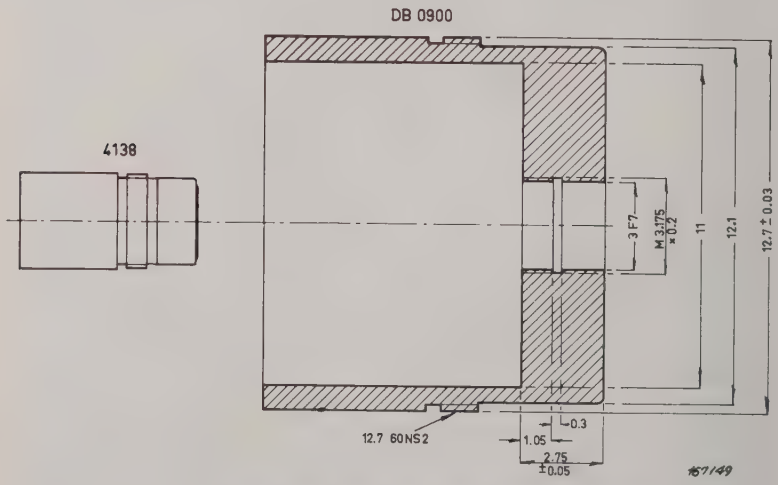


Fig. 2.2. Eighth-inch cartridge and adaptor DB 0900.

Probe Microphone Kit UA 0040.

Probe microphones can be used for a variety of applications such as measurements in the ear, measurements on sound insulating materials and within intricate machinery, as well as in other inaccessible places, e.g. small ducts, furnaces, oilburners, etc. The Kit includes 4 probe tubes, adaptor and gasket for mounting on the B & K 1/2" microphone cartridges, or quarter-inch provided with the adaptor DB 0264 or eight-inch microphone cartridge provided with the above mentioned adaptor DB 0900. The outside diameters of the 4 probes

Fig. 2.3. The Probe Microphone Kit Type UA 0040.

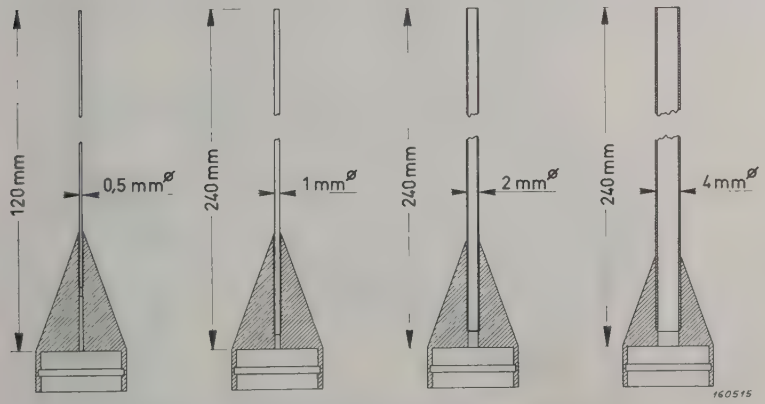


Fig. 2.4. Sectional drawing of the probe tubes.

are: 0.5, 1, 2, and 4 mm, and the length is 240 mm (except for the 0.5 mm diameter probe which is 120 mm long).
In addition, a coupler accepting the 4 different probe tube diameters is supplied together with a small earphone enabling determination of the frequency response curves of the probe microphone by means of a B & K Beat Frequency Oscillator. The response of the probes may be adjusted as illustrated in Fig. 2.5.
The requirement of length and width of the probes will vary with the applications. The necessary tools and damping material to make them suitable for any particular application are supplied with the Kit. The detailed description and the instructions for use of the UA 0040 are contained in the manual 4133/4134.

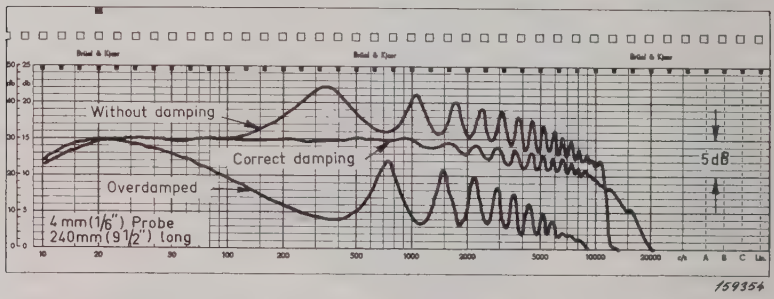


Fig. 2.5. Example of frequency response of a probe microphone with different degrees of damping.

Two-Channel Microphone Selector Type 4408.

This instrument enables the user to make comparisons between the outputs of two B & K condenser microphones by connecting them alternately to a

Fig. 2.6. Two-Channel Microphone Selector Type 4408.

single indicating device. (The B & K microphone amplifiers and analyzers are able to power two cathode followers at a time).
The switching can be done manually by means of a toggle switch on the top of the instrument, or automatically by remote control of the relay. The external switch then replaces the function of the toggle switch. The simultaneous recording of the two signals may thus be driven from the Level Recorder Type 2305 which is provided with a switch operated in synchronism with the paper drive.
Crosstalk is kept to negligible proportions by extra filtration in the anode supply circuits to the cathode followers.

Microphone Power Supply Type 2801.

The Microphone Power Supply is for example used in conjunction with tape recording of measurement data in the field in cases where B & K Amplifiers or Analyzers are not available, or where extremely long extension cables must be used between the microphone and the succeeding amplifier. The power supply unit supplies the necessary filament, anode and polarization voltage for the microphones, and, in addition, it contains a transformer stage to convert the output impedance of the cathode follower into an impedance of 50 ohms (voltage ratio 1/6.3) or 200 ohms and 200 ohms symmetrical (voltage ratio 1/3.16).

Fig. 2.7. Microphone Power Supply Type 2801.

The power supply unit is heavily stabilized for variations in mains voltage and may be operated from power outlets with 100–115–127–150–220 or 240 volts (50 to 400 Hz).
The Microphone Power Supply can also be employed in conjunction with the above mentioned Microphone Selector Type 4408. For further details the reader is referred to the separate instruction manual for Type 2801.

Two-Channel Power Supply Type 2803.

The Two-Channel Power Supply Type 2803 is intended for use in connection with two of the B & K Cathode Followers. It delivers anode, filament and polarization voltages, and converts the output impedance of the cathode follower into a lower impedance (15 Ω), this being necessary when very long cables have to be used between the microphones and the succeeding amplifier.

It will allow the use of two channels simultaneously, or enable switching either manually or automatically between the two channels to one set of recording instrumentation connected to the output. The two inputs can be connected to the two output sockets in several combinations determined by the position of the FUNCTION SELECTOR knob. The combinations are as follows:

1. Input 1 – Output 1.
   Input 2 – Output 2.
2. Input 1 – Output 1.
3. Input 2 – Output 1.
4. Input 1 or 2 – Output 1.
   Switching between the inputs in this position (4) is carried out by a set of relay contacts which can be externally controlled from the Level Recorder's "Two-Channel Selector" switch or by grounding the socket marked "Pol. Volt – Ext. Control".
5. Same as 4. but the switching between the channels is now controlled by a built-in multivibrator having a fixed switching frequency of about 0.5 Hz.

In all positions of the FUNCTION SELECTOR knob, individual attenuation of the signals is made possible between 0 and 40 dB re. to the input.

Fig. 2.8. The Two-Channel Power Supply Type 2803.

Appendix

Principle of the Condenser Microphone.

A condenser microphone consists essentially of a thin metallic diaphragm mounted in close proximity to a rigid back plate. Diaphragm and back plate are electrically insulated from each other and constitute the electrodes of a capacitor. See Fig. A.1. Housing and insulator form with the diaphragm a closed chamber, which is only in communication with the outside for slow static ambient pressure variations. When the microphone is exposed to a sound pressure, the diaphragm is submitted to an alternating force proportional to the pressure and the diaphragm area. The consequent movement of the diaphragm varies the capacity, and these variations are transduced into an AC voltage component if a constant charge is present between the electrodes. The charge is obtained by means of a stabilized DC polarization voltage, and it remains constant as long as the charging time constant of the circuit is much longer than the period of the sound pressure variations. It is possible by careful design to maintain the proportionality of the AC output voltage to the sound pressure within a wide frequency range and an extended dynamic range. The widest linear frequency range for the pressure response is obtained if the resonance of the mechanical system (diaphragm) is critically damped. This damping, which is due to the back-and-forth movement of the air contained between diaphragm and back plate, is determined by the shape of the back plate, the mechanical tension of the diaphragm, and the spacing between plate and diaphragm.

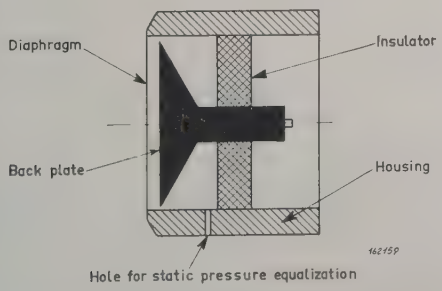
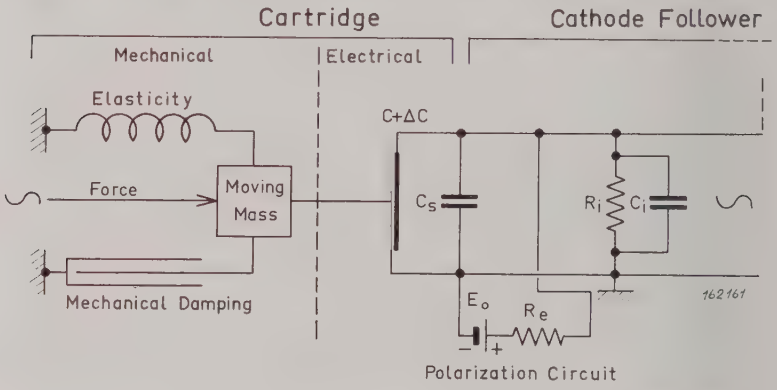


Fig. A.1. Schematic construction of a condenser microphone cartridge.

The low frequency limit of the linear range is set by the "cut-off" (or time constant) of the microphone cartridge circuit. Referring to the schematic diagram of Fig. A.2 the cut-off frequency is:

$$f_o = \frac{1}{2\pi (C + C_s + C_i) \dfrac{R_i R_e}{R_i + R_e}}$$

Since the sensitivity of the microphone is determined by the relative variation of capacity $\Delta C/(C + C_s + C_i)$, the total parallel capacity should be made as small as possible. The first amplifier stage is therefore built in the same housing as the microphone. A cathode follower stage providing a very large input impedance is employed, because small parallel capacity requires high R_i and R_e in order to obtain a satisfactory low limiting frequency.



C = Polarized cartridge capacity

ΔC = Variation of capacity producing the signal

C_s = Stray capacity of connection to cathode follower

$R_i C_i$ = Input impedance of cathode follower

Fig. A.2. Simplified diagram of the condenser microphone. (The electrical leakage in the cartridge is omitted).

Microphone Calibration.

Error in an Absolute Sound Level Measurement.

Considering the various standard errors*) a, b, c - - - which are expected to occur on each of all the different parts of the measuring arrangement, the total standard error is $S = \sqrt{a^2 + b^2 + c^2 + \text{- - - -}}$

In the case of the measuring arrangement of Fig. 1.2, for example, the different

*) The standard error s is such that there is 68 % chance of obtaining errors smaller than s, 90 % smaller than 1.65 s and 99 % smaller than 2.58 s.

sources of error to be considered in the measurement of the sound pressure level on the microphone diaphragm are as follows (rough estimation):

(a) Microphone cartridge calibration: 0.2 dB after proper corrections.
(b) Transmission loss of the cathode follower and loading of the cartridge: 0.1 dB.
(c) Polarization voltage's deviation from 200 V: 0.2 dB.
(d) Voltage calibration of the 2603: 0.1 dB.
(e) Meter scale and attenuators: 0.2 dB.
(f) Reading error: 0.1 dB.
(g) Uncertainty on the frequency response of the measuring equipment, which should be taken into account when considering bands of noise having frequencies differing greatly from the frequency of microphone calibration (250 Hz). Still considering the equipment of Fig. 1.2, this uncertainty is about ± 0.1 dB from 100 Hz to 20 kHz, and ± 0.3 dB from 50 Hz to 50 kHz for a free-field measurement at 0° incidence with the 4135. When measuring broad band noise through the A-B-C weighting networks of the 2604 the probable frequency response uncertainty is of the order ± 0.3 dB.

Equating 0.1 dB to 1.1 %, 0.2 dB to 2.2 % and 0.3 dB to 3.3 %, the standard error in the measured result will thus be

$S = \sqrt{2.2^2 + 1.1^2 + 2.2^2 + 1.1^2 + 2.2^2 + 1.1^2 + 3.3^2} = 5.4\ \% = \pm 0.48$ dB and the probability of obtaining larger errors than 0.8 dB is less than 0.1.

Note: In some cases of irregular statistical distribution of signal amplitudes, errors may be caused by the limited averaging time (damping) of the meter or by the limitation of the RMS rectifier possibilities.

If a better accuracy is desired, the most practical and reliable solution is to make a direct calibration of the whole measuring arrangement before each series of measurement by means of a calibrated sound source. Then the errors (a) (b) (c) (d) outlined above are replaced by the source calibration error and the calibrating reading error. When using a Pistonphone Type 4220, these errors may be estimated each to 0.1 dB. The total standard error is then reduced to S = 0.40 dB (0.27 dB for pure tones, for which error (g) may be eliminated).

Pistonphone Type 4220.

The Pistonphone Type 4220 (Fig. A.3) is a small, portable battery-driven unit weighing only 1.5 lbs. which is extremely well-suited for field calibration. The pistonphone produces, when fitted to a B & K microphone, a sound pressure level of 124 dB at 250 Hz which is known with an error of less than ± 0.2 dB. This enables a direct calibration in dB SL of a meter scale to be made, and measurements therefore to be taken with an excellent accuracy if the frequency response and the dynamic linearity (including the attenuators) of the instrumentation following the microphone are ascertained. A barometer is supplied with the instrument for direct reading of ambient pressure corrections, together with adaptors for fitting to the different B & K microphones.

Fig. A.3. Pistonphone Type 4220 in case with Barometer and Coupling Adaptors for fitting to the different B & K microphones.

Electrostatic Actuator Type UA 0033.

The diaphragm of a condenser microphone may be influenced by electrostatic attraction in a way which is similar to the action of sound waves. This is done very simply by placing a metallic grid in close proximity to the diaphragm and applying an alternating voltage between them. A test signal of constant amplitude and varying frequency is thereby easy to obtain The grid is shaped in a way which allows free movement of the air situated between grid and diaphragm in order to ensure that only the electrostatic attraction is communicated to the microphone. Since the attraction is proportional to the square of the voltage, the test frequency is doubled. The Electrostatic Actuator Type UA 0033 (Fig. A.4) is designed for use with the half-inch, quarter-inch and eighth-inch condenser microphones. The actuator is placed on the microphone held vertically. It has three glass studs which contact the periphery of the cartridge diaphragm and give an accurate spacing of a few tenths of millimeters between actuator grid and diaphragm. In the case of the quarter-inch and eighth-inch, an adaptor DB 0264 or DB 0900 respectively is screwed onto the cartridge with its front "flush" to the cartridge diaphragm.

When using a BFO Type 1013 as voltage source, the maximum available voltage of 120 volts will provide an equivalent sound pressure level in the

order of 80 dB which generally is sufficiently above the ambient noise level in laboratories. A higher signal level may be obtained by using the 800 volts DC bias provided by the Microphone Calibration Apparatus Type 4142. This is the method used in production at B & K.
Since the fictive pressure is not affected by ambient conditions, the actuator is an excellent means for the determination of the variations in microphone sensitivity under changing environments.

Fig. A.4. Electrostatic Actuator Type UA 0033.

The Range of B & K Condenser Microphones.

The following figures and tables describe the compared characteristics of the different types of condenser microphones made by B & K. They are all of similar construction, but differ in dimensions, the smaller diameters giving higher limits of the frequency and dynamic range at the expense of a lower sensitivity.

For detailed description, the reader is referred to the respective Instruction Manuals. However a rough estimation of the general characteristics of all types may be obtained by extrapolation of the characteristics described in this manual for the quarter-inch microphones.

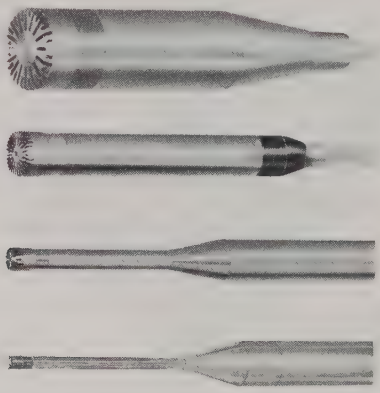


Fig. A.5. From top to bottom:
Type 4131/32 + 2613 (23.77 mm outside diameter)
Type 4133/34 + 2615 (12,7 mm outside diameter)
Type 4135/36 + UA 0035 + 2615 (6.35 mm outside diameter)
Type 4138 + UA 0036 + 2615 (3.175 mm outside diameter)

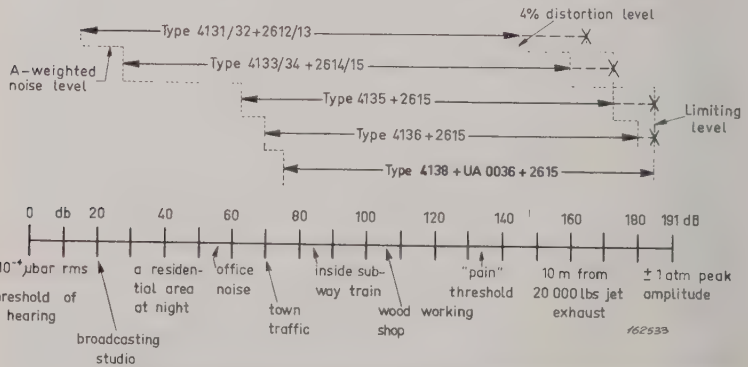


Fig. A.6. Compared dynamic ranges of the B & K condenser microphones.

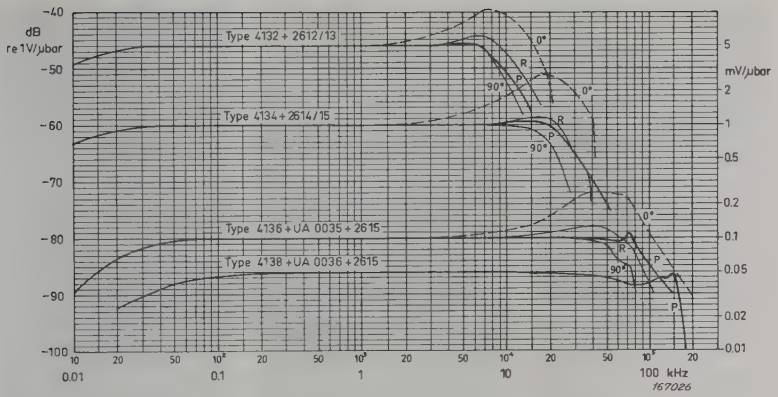


Fig. A.7. Frequency response of the different B & K condenser microphones without accessories.

0° = free-field response at 0° (normal incidence)
90° = free-field response at 90° (grazing incidence)
R = random incidence response (diffuse field)
P = pressure response (towards higher frequencies, the slope is about −12 dB/octave)

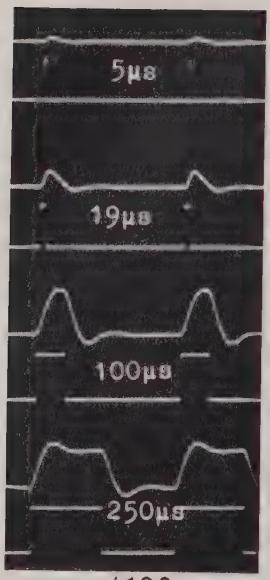
N.B. Valid with protecting grid for types 4131–34 (1" and 1/2") and without protecting grid for types 4135–36 (1/4") and 4138 (1/8") with exception of the dotted "R-curve" of 4135 which is with grid.

Fig. A.8. Compared pulse-response of the B & K microphones. From left to right: 1" (4132), 1/2" (4134), 1/4" (4136). →

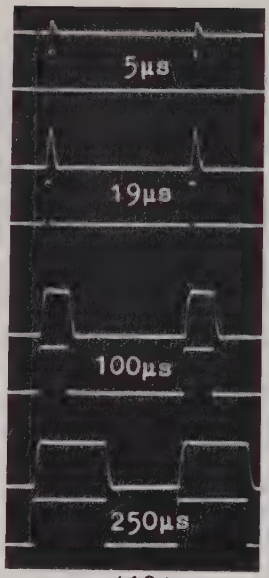
The microphone is actuated electrostatically by positive rectangular pulses at a pulse recurrence frequency of 2000 Hz with different crest factors (peak amplitude/RMS value). Input pulses are represented under the corresponding output pulses.

Above, from top to bottom: crest factors of 10, 5, 2, and 1 (pulse duration of 5, 19, 100 and 250 μs).

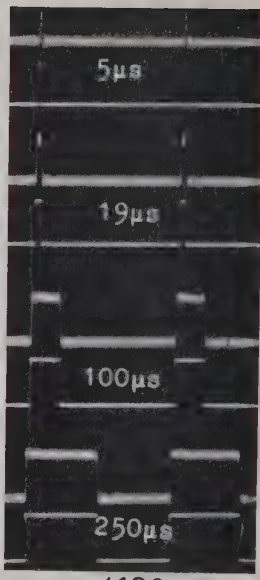
Below: enlarged pulse pictures with horizontal scanning velocity multiplied by 5 for the 4132 and 10 for 4134 and 4136. Unenlarged pictures are represented under the corresponding enlarged pictures. Crest factors 3 and 5 for the 4132 and 5 and 10 for 4134–4136 are enlarged and show that the condenser microphones have practically no ringing.



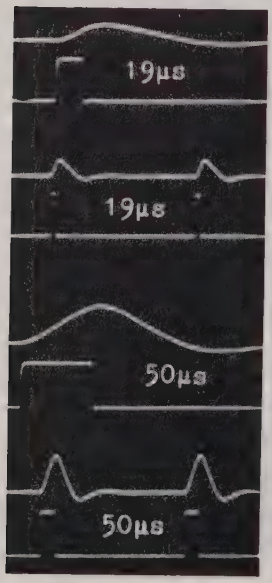
4132

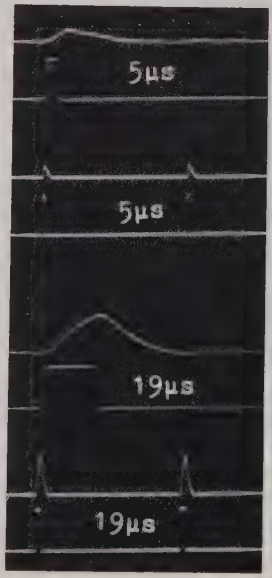


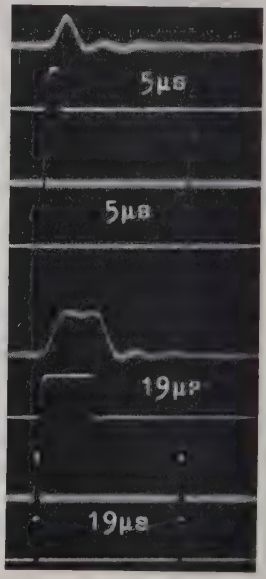
4134



4136







162565

Survey of Accessories available for each Microphone Series (1", 1/2", 1/4", 1/8" diameter)

Description		1" Type	1/2" Type	1/4" Type	1/8" Type
Microphone Cartridge		4131-32	4133-34	4135-36	4138
Cathode Follower	goose-neck type	2612	2614	2614[1]	2614[7]
	with 2 m long cable	2613	2615	2615[2]	2615[7]
	battery driven	2630	2630[3]		
	insert voltage	2617			
Front Covers	Random incidence corrector	UA 0055			
	Windscreen	UA 0082	UA 0082		
	Nose cone	UA 0051	UA 0052	UA 0053	
	Rain cover		UA 0056		
	Probe microphone kit		UA 0040	UA 0040[4]	UA 0040[8]
Mountings	Flexible Adaptor (f. sidemount.)		UA 0122	UA 0122	
	Flexible Adaptor (f. endmount.)		UA 0123	UA 0123	
	Extens. Connector (fitting 2612-13-30).	UA 0039	UA 0039		
Calibration	Electrostatic actuator	UA 0023	UA 0033	UA 0033[4]	UA 0033[8]
	Pistonphone	4220			
	Reciprocity calibration app.	4142			
Acoustical Couplers	Artificial mouth		4210		
	Artificial ear	4152	4152[5]		
	6 cm³ ASA-Z 24.5.1951	DB 0160	DB 0160[5]		
	6 cm³ ASA-Z 24.9. 1949	DB 0161	DB 0161[5]		
	2 cm³ ICE 126-1961	DB 0138	DB 0138[5]		
	Coupler adapting ring	DB 0111			
Cartridge extension cable (3 m, for use with 2203)		AO 0003			
Extension cables (3 m - 10 m - 30 m) Tape microphone cable (0.3 m)		AO 0027-28-29 AR 0001			
Microphone stands		UA 0049			
Microphone power supply		2801-2803			
Two-channel microphone selector		4408			
Sound measuring equipment[6]	Portable sound level meter	2203			
	Portable octave filter set	1613			
	Sound level meter	2603 - 2604			
	Spectrometer (1/1 and 1/3 oct.)	2112 - 2211 - 2212			
	Frequency analyzer	2107			

[1]) Add Adaptor UA 0035 or UA 0057 and Cable AO 0028.
[2]) Add Adaptor UA 0035 or UA 0057.
[3]) Add Adaptor UA 0030 or UA 0089 or AO 0033.
[4]) Add 1/4"—1/2" Adaptor DB 0264.
[5]) Add 1/2"—1" Adaptor DB 0225.
[6]) Following the recommendations of the IEC for Precision Sound Level Meters.
[7]) Add Adaptor UA 0036.
[8]) Add Adaptor DB 0900.

COMPARATIVE SPECIFICATIONS

Type	4131 + 2612/13	4132 +2612/13	4133 +2614/15	4134 +2614/15	4135 + UA 0035 + 2615	4136 + UA 0035 + 2615	4138 + UA 0036 + 2615
Nominal Cartridge Diameter	1 inch		½ inch		¼ inch		⅛ inch
Frequency Response*) See Fig. 3. Flat within ± 2 dB in the range:	**Free-field (0° incidence)** 20 Hz to 18 kHz	**Pressure** 20 Hz to 7 kHz	**Free-field (0° incidence)** 20 Hz to 40 kHz	**Random incidence and Pressure** 20 Hz to 20 kHz	**Free field (0° incidence)** 30 Hz to 100 kHz	**Random incidence and Pressure** 30 Hz to 70 kHz	**Random incidence and Pressure** 30 Hz to 140 kHz
Sensitivity*) at cathode follower output	5 mV/μbar –46 dB re. 1 V/μbar		1 mV/μbar –60 dB re. 1 V/μbar		0.2 mV/μbar –74 dB re. 1 V/μbar	0.1 mV/μbar –80 dB re. 1 V/μbar	50 μV/μbar –86 dB re. 1 V/μbar
Cartridge open-circuit sensitivity*)	–45 dB re. 1 V/μbar		–58 dB re. 1 V/μbar		–70 dB re. 1 V/μbar	–76 dB re. 1 V/μbar	–86 dB re. 1 V/μbar
Dynamic Range (from equivalent A-weighted noise level to 4 % harmonic distortion)	15–146 dB re. 0.0002 μbar		32–160 dB re. 0.0002 μbar		64–174 dB (10 %) re. 0.0002 μbar	70–180 dB (10 %) re. 0.0002 μbar	76–184 dB (10 %) re. 0.0002 μbar
Resonant Frequency (90° phase angle)	10 kHz	8 kHz	25 kHz	25 kHz	75 kHz	75 kHz	
Polarization Voltage	200 V						
Polarized Cartridge Capacity*)	70 pF	60 pF	20 pF		6.4 pF		
Equivalent Air Volume (at 1 atm.)	0.15 cm^3	0.15 cm^3*)	0.01 cm^3	0.01 cm^3*)	0.0005 cm^3		< 0.0001 cm^3
Temperature Range: up to	100°C	100°C	with 2614: 150°C (continuous) 250°C (intermittent) with 2615: 100°C (limited by cable insulator)				
Temperature coefficient between –50°C and +60°C	less than ± 0.01 dB/°C						
Ambient Pressure Coefficient (increase of sensitivity for a 100 mm Hg decrease of pressure)	0.2 dB		0.1 dB		less than 0.1 dB		
Relative humidity influence	less than 0.1 dB (in the absence of condensation)						
Dimensions of cartridge: without protecting grid with protecting grid	diameter / height 23.77 mm (0.936") / 17 mm (0.67") 23.77 mm (0.936") / 19 mm (0.75")		diameter / height 12.7 mm (½") / 11 mm (0.43") 13.2 mm (0.52") / 12.7 mm (½")		diameter / height 6.35 mm (¼") / 9 mm (0.35") 7 mm (0.275") / 10.5 mm (0.41")		diameter / height 3.175 mm (⅛") / 6.0 mm (0.240") 3.50 mm (0.140") / 6.7 mm (0.268")
Thread: grid (or coupler) mounting cathode follower mounting	23.11 mm (0.91") – 60NS2 23.11 mm (0.91") – 60NS2		12.7 mm (0.50") – 60NS2 11.7 mm (0.46") – 60NS2		6.35 mm (0.25") – 60NS2 5.7 mm (0.22") – 60NS2		M 3.175 × 0.2 M 3 × 0.25

*) Individually calibrated.

Brüel & Kjær
Copenhagen

Type 4138

Number Anzahl Nombre Antal	Type	Accessories for Condenser Microphone Cartridge Description	Zubehör für Kondensator-mikrophonkapsel Bezeichnung	Accessoires pour Cartouche de Microphone à Condensateur Dénomination	Tilbehør for Kondensator-mikrofon kapsel Betegnelse
1	BA 4138	Instruction manual in plastic cover	Gebrauchsanweisung in Plastikumschlag.	Manuel d'instruction sous couverture plastique.	Brugsanvisning i plastikomslag.
1	KE 4138	Case.	Schachtel.	Coffret.	Etui.
1	BC 0020	Calibration chart for cartridge. (in the case).	Eichkarte für Kapsel. (Liegt in der Schachtel).	Feuille d'étalonnage (dans le coffret).	Kalibreringskort for kapsel. (ligger i etuiet).

204690
Bx 0082

ORBOE PRINT . COPENHAGEN . DENMARK

September 1967